

WELD CERTIFICATION PLAN FOR THE ALPHA MAGNETIC SPECTROMETER - 02 (AMS-02) SUPER FLUID HELIUM TANK AND RELATED CRYOGENIC SYSTEM

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ACRONYMS AND ABBREVIATIONS

AMS	Alpha Magnetic Spectrometer
AWS	American Welding Society
JSC	Lyndon B. Johnson Space Center
LMSO	Lockheed Martin Space Operations
MSFC	Marshall Space Flight Center
NASA	National Aeronautics And Space Administration
NDE	Non-destructive Evaluation
PQR	Procedure Qualification Records
SOP	Standard Operating Procedure
SPEC	Specification
STA	Structural Test Article
STD	Standards
TBD	To Be Determined
WOPQR	Welding Operators Performance Qualification Records
WPQR	Welder Performance Qualification Records
WPS	Weld Procedure Specification

1.0 SCOPE

The plan provided herein encompasses the requirements for qualifying all welding that is performed on hardware for the Super Fluid Helium Tank and associated cryogenic systems that support the AMS payload and payload qualification and/or replica ground test units (e.g. both the Flight and Structural Test Article (STA) tanks).

2.0 GOVERNING REQUIREMENTS

The requirements set forth in MSFC-SPEC-504C and MSFC-SPEC-560A for aluminum and steel alloys respectively, are the referenced documents that govern the stated requirements in this document. Therefore, these documents form a part of this certification plan to the extent specified herein. This document is written so as to be an overview of these requirements. Therefore, the MSFC and other underlying documents should be referenced when necessary for clarification of the details of these requirements. Where a conflict is apparent, the applicable MSFC specification shall preside.

3.0 APPLICABILITY

These requirements cover all fusion welds made by any variation of the Gas Tungsten Arc Welding (GTAW) process or the Plasma Arc Welding (PAW) process including AC, SWAC, DC, and VP process modes. Any other proposed processes must be approved by representatives from NASA/LMSO. Coverage includes any weld made by manual, semiautomatic, automatic, or robotic applications. All welds shall be qualified to requirements representing MSFC Class I specifications.

4.0 BASE MATERIALS

These requirements cover aluminum alloys and steels that are proposed for the AMS cryogenic systems. All base materials used for qualification weld testing shall be procured to the same specifications as the material used for the flight hardware including trace ability requirements.

5.0 FILLER METAL

All filler metals and electrodes used for qualification testing shall be procured and controlled per NASA/JSC SOP-004.5.

6.0 TERMS AND DEFINITIONS

Where specific welding terminology and applicable definitions are used, they shall be per the American Welding Society (AWS) A3.0 standard (latest version); "Standard Welding Terms and Definitions." Where specific welding symbols are used, they shall be per the AWS A2.4 standard (latest version); "Standard Symbols for Welding, Brazing, and Nondestructive Examination."

7.0 TESTING

All testing shall be performed in accordance with AWS B4.0; Standard Methods for Mechanical Testing of Welds." Specialized testing not covered by the aforementioned shall be performed per TBD. Number and types of tests shall be per the applicable paragraphs listed herein. Except for bend tests, all non-destructive evaluation (NDE) and mechanical testing shall be performed on the samples with the weld in the final condition it is expected to be in on the production hardware (i.e., weld reinforcement left intact, weld reinforcement shaved flush, weld size, weld bead rolled, etc.).

8.0 AUTOMATED WELDING EQUIPMENT

Automated welding equipment (automatic and semi-automatic) shall have valid and current calibrations on all dials, meters, direct reading electrical control circuits, and recorders that are used to indicate essential welding parameter settings and/or output. Essential welding parameters are those process variables that require control during the process within a specific range so as to not violate the weld qualification. At a minimum, the heat input related process variables, amperage (current), voltage, and travel speed shall be considered essential process parameters and therefore shall be monitored by calibrated instruments.

9.0 MANUAL WELDING EQUIPMENT CALIBRATION

Manual welding equipment shall not be required to have calibrated instrumentation however, reference indicating instrumentation shall be functional (useful output), in good working order, and the production ready equipment shall be capable of producing sound welds when used by a certified welder performing work to a qualified and certified welding procedure.

10.0 WELDER AND WELDING OPERATOR PERFORMANCE QUALIFICATION

Welders and welding operators required to perform production welding with manual, semiautomatic, and automatic equipment shall be qualified in accordance with AMS-STD-1595 for the alloy group and filler metal group applicable to the production welds. In addition, welding operators shall be qualified on the automatic calibrated production equipment. Welder and welding operator qualification testing shall be performed using a qualified welding procedure. However, if during production of a test plate to qualify a welding procedure, the tests are deemed acceptable, this shall also qualify the welder or welding operator within the limits specified by AMS-STD-1595. Wherever practical, it is recommended that a weld procedure qualification test be used to qualify a production welder in the expected production orientation (position), and visa versa (i.e., a welder performance qualification should be used to qualify a production welding procedure). Alternatively, AMS-STD-2219 may be used in lieu of AMS-STD-1595.

11.0 WELDING PROCEDURE QUALIFICATION

All welds on production hardware shall be made using a procedure qualified per AWS B2.1 "Special Test Weldments" (reference Section 3 in MSFC-SPEC-504C) except that minimum strength requirements for qualification testing shall be as specified by the AMS-02 SFHe structural analysis requirements. Special Test Weldments are required to be representative of the thickness for which the qualification represents, therefore the test plates shall be produced from the same thickness and plate orientation as the production hardware is produced from. This qualification plan takes some exception to this rule by only requiring a single test plate to cover multiple thickness qualifications, where the thicknesses are considered to be relatively similar. For multiple pass weld joints that end up being machined into complex geometries (e.g., Helium Vessel Central Ring), testing shall include samples representing each direction of the thinnest section

in each local axial direction. As an alternate approach, full section testing may be performed on the finished production geometry.

12.0 DOCUMENTATION

Welder Performance Qualification Records (WPQR), Welding Operators Performance Qualification Records (WOPQR), Welding Procedure Qualification Records (PQR), and production Welding Procedure Specifications (WPS) shall be documented in a suitable format and kept on record at the manufacturer until all AMS flight hardware returns from space. WPSs shall be kept in the production area and shall be utilized for all production welding. WPSs shall be clearly referenced on all shop router documentation. Welders and welding operators whom perform work to a router shall be required to sign off the applicable router sequence to ensure positive and thorough fabrication traceability. All documentation listed above shall also be sent to and certified by representatives from NASA/LMSO.

13.0 REQUIRED TESTS

Table 13-1 outlines the required weld tests to support the Super Fluid Helium Tank weld qualification on 5083 aluminum and pure aluminum (tubing).

Table 13-2 outlines the required weld tests to support the Super Fluid Helium Tank weld qualification on 300 Series CRES.

For each line item in the tables, a minimum of one test plate is required for qualification testing provided the dimensions of the test plate provide ample weld length and width to extract all of the test specimens required in Table 15-1.

14.0 TEST PLATE CONFIGURATION

AWS B2.1 shall be used as a guideline for test plate minimum size and configuration for manual weld procedure qualification. To ensure the validity of the automatic welding procedure qualifications, the test plate configuration shall be a minimum 2X the length dimension given in B2.1 and all other dimensions may remain the same. The only exception will be the 30mm thick qualification test plate. This test plate configuration shall have the width dimensions adjusted accordingly to accommodate the higher

expected heat inputs required to make this weld and the potential need for larger than normal tensile specimens to ensure the validity of the test results.

TABLE 13-1 REQUIRED WELD TESTS TO SUPPORT SFHE TANK WELD QUALIFICATION ON 5083 AL AND PURE AL (TUBING)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	THKNS (mm)***	THKNS (in)***	APPL DRWG	APPL PART NAME	WELD TYPE	AUTO WELD	MAN WELD	XRAY	DYE PEN	RT TENSILE	BEND	MACRO	FILLET SHEAR	FRAC TOUGH	CRYO** TENSILE
A	30	1.170	SCD0905-01	Central Ring	Groove	X		X	X	X	X*	X			X
B	3 to 6.3	0.117 to 0.246	SCD0905-02 SCD0905-03 and SCD0905-04 SCD0905-05	Internal Stiffener Ribs for Outer/Inner Rings	Fillet	X			X			X	X		
C	4 to 4	0.156 to 0.156	SCD2035	DCLM Transition Socket	Fillet		X		X				X		
D	3 or 4.8	0.117 or 0.187	SCD0905	Welded Socket 20-24 Places and Alum to CRES Trans Sockets and Thru Tube End Cap to Top/ Bottom Vessel Dish and Burst Thru Disc Port to Lower End Dish	Groove		X	X	X	X	X	X			X
E	4.65 or 4.8	0.181 or 0.187	SCD0905	Thru Tube End Cap to Top/ Bottom Inner Cylinder	Groove	(X)	X	X	X	X	X	X			X
F	4	0.156	SCD0905	Thru Tube to Outer Thru Tube End Cap	Groove	X	(X)	X	X	X	X	X			X
G	3	0.117	SCD0905	End Dishes to Upper/Lower Tank Bodies	Groove	X		X	X	X	X	X			X
H	4	0.156	SCD0905	Central Ring to Outer Rings	Groove	X		X	X	X	X	X			X
I	6	0.234	SCD0905	Central Ring to Inner Rings	Groove	X		X	X	X	X	X			X
J	1 to 1.5	0.039 to 0.059	SCD2036	Internal Tubing Arrangement	Groove		X	X	X	X	X	X			X

* Full side bends and face/root bends from middle 1/5th of weld plate.

** Cryogenic testing will be done at 7 K.

*** Thickness provided for reference only. Actual references are per SCL drawings.

(X) Weld may be performed in this manner.

TABLE 13-2 REQUIRED WELD TESTS TO SUPPORT SFHE TANK WELD QUALIFICATION ON 300 SERIES CRES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	THKNS (mm)	THKNS (in)	APPL DRWG	PART NAME	WELD TYPE	AUTO WELD	MAN WELD	XRAY	DYE PEN	RT TENSILE	BEND	MACRO	FILLET SHEAR	FRAC TOUGH	CRYO TENSILE
A	1 or 2	0.039 or 0.078	SCD2032 and SCD2020	Porous Plug Assembly and Burst Thru Disc Inner Sleeve to Vessel Port Transition Element and Burst Thru Disc to Inner Sleeve and other similar feed-thru sections	Groove	(X)	X	X	X	X	X	X			X

(X) Weld may be performed in this manner.

15.0 TEST SPECIMEN QUANTITIES

Table 15-1 outlines the required quantities of test specimens to be taken from each test plate.

TABLE 15-1 REQUIRED QUANTITIES OF TEST SPECIMENS FROM EACH TEST PLATE

	1	2	3	4	5	6	7	9	10
	Weld Type	AUTO WELD	MAN WELD	RT TENSILE	BEND	MACRO	FILLET SHEAR	FRAC TOUGH	CRYO TENSILE*
A	Groove	X		5	4**	2			2
B	Groove		X	5	4	2			2
C	Fillet	X				2	5		
D	Fillet		X			2	5		

* Cryogenic testing will be done at 7 K.

** 2 root side and 2 face side bends. Where side bends are used in place of root/face bends, 4 shall be required.

16.0 TEST PLATE LAYOUT

AWS B2.1 shall be used as a guideline for test plate layout. As a general rule, because multiple types of specimens are to be taken from each test plate, the specimens should be randomly distributed about the length of the plate with no one specimen type taken immediately adjacent to the same specimen type. Specimens shall not be taken within the first and last ½ inch of the test plate length and the run-on/run-out regions, as this area is considered “drop off” and shall not be subject to the NDE inspection evaluation nor to the mechanical and metallurgical testing protocol.